Spring 5-11-2016

Comparison of Combustion Efficiency to In-Situ Atmospheric Ammonia Measurements from a Miniature Chemical Ionization Mass Spectrometer in the LA Basin

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Results

Atmospheric ammonia (NH₃) has been shown to impact the environmental and threaten both human and animal health, especially in heavily populated urban areas, yet to date there remains a paucity of direct measurements. Recent studies have suggested that ammonia may be generated as a byproduct of fossil fuel emissions due to highly active catalytic converters in light-duty gasoline vehicles. To investigate this relationship, an airborne miniature Chemical Ionization Mass Spectrometer (miniCIMS) was used to directly measure atmospheric ammonia and combustion reaction products in the Southern California LA Basin, during the 2015 NASA Student Airborne Research Program (SARP). The temporal variability in measured ammonia, and the relationship to combustion efficiency will be compared to mobile ground-based measurements from the NASA DISCOVER-AQ campaign, and implications of the findings will be discussed.

NASA DISCOVER-AQ

Figure 1: 2015 SARP on June 23, “Morning” Flight at 9:38 am – 10:05 am; “Missed approach”, through LAX. The max amount of NH₃ was detected during the “Morning” Flight was 21.56 [NH₃] ppbv.

Figure 2: 2015 SARP on June 23, “Afternoon” Flight at 2:18 pm – 2:30 pm “Missed approach”, through LAX. The max amount of NH₃ was detected during the “Afternoon” Flight was 14.11 [NH₃] ppbv.

Figure 3: Comparison of NH₃ at varying altitudes between, “Morning Flight” and “Afternoon Flight” SARP 2015 June 23rd flights through LAX.

Conclusions:

During the SARP 2015, novel miniCIMS was able to detect elevated ambient ammonia during these two missed approaches through Los Angeles International Airport. The “Morning” Flight was conducted at 9:38 am – 10:05 am and “Afternoon” Flight was conducted at 2:18 pm – 2:30 pm on June 23rd had respective mean concentrations of 6.0465 [NH₃] ppbv for the “Morning” Flight and 3.8282 [NH₃] ppbv for the “Afternoon” Flight.

Both flights, which flew similar tracks and at similar pressure altitude, but experienced different concentrations of NH₃. The max 25.16 [NH₃] ppbv “Morning” Flight compared to the max 14.11 [NH₃] ppbv for the “Afternoon” Flight.

Figure 4: [NH₃] Mean comparison between 2015 SARP “Morning” Flight at 9:38 am – 10:05 am and “Afternoon” Flight at 2:18 pm – 2:30 pm on June 23 through Los Angeles Basin. The respective mean concentrations were found to be 6.0465 ppbv for the “Morning” Flight and 3.8282 ppbv for the “Afternoon” Flight.

Figure 5: Comparison of [CO]/[CO₂] combustion efficiency for 2015 SARP on June 23rd through LAX.

Figure 6: The relative frequency and time evolution of on-road (NH₃) distributions for L.A.

Figure 7: Comparison of relative frequency of airborne ammonia NH₃ (ppbv) on June 23rd 2015 SARP through LAX.

Figure 8: [NH₃]/[CO] mean conducted by Mark Zondlo for On Road Ammonia Emissions Characterized by Mobile, Open-Path Measurements, 2014.

Figure 9: Comparison of [NH₃]/[CO] Mean 2015 SARP on June 23rd through Los Angeles International Airport. [NH₃]/[CO] mean was 0.0464 ppbv/ppbv for the “Morning” flight and 0.0308 ppbv/ppbv for the “Afternoon” flight.